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Making Teams: Impact on Team Process and Outcome

PRINCIPAL INVESTIGATOR(S): Linda R. Elliott
Cynthia O. Guerrero

CONTRACTING ORGANIZATION: Armstrong Laboratory
Brooks Air Force Base, Texas 78235
and
Systems Research Laboratory
San Antonio, Texas 78235

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Introduction

Military effectiveness relies on the performance of individuals within interdependent team contexts. Team members in tactical decision making situations such as command and control must make decisions under conditions of high stakes, time pressure, and ambiguous or conflicting information. USAF Airborne Warning and Control System (AWACS) teams exemplify this type of team decision context. In this context effective performance relies upon accurate interpretation and coordination of information among interdependent team members.

While effective performance depends upon well informed and coordinated teams, it has been found that teams composed of members differing in gender or other demographic characteristics have been linked to both positive and negative outcomes (Jackson, May, & Whitney, 1995). Teams of all-male members have performed more effectively than all-female teams on quantitative problem solving tasks, and yet it was also found that mixed-sex teams performed better than same-sex teams on problem solving tasks (Wood, 1987). In her meta-analysis, Wood noted the conflict in research findings regarding the effect of gender differences in team performance, and encouraged the systematic examination of the impact of gender on group process variables such as interaction behaviors. In her review of meta-analytic studies, Eagley (1995) reported general agreement of stable sex-related differences in social behavior and personality.

There is not a lot of previous research on the effect of gender on interaction behaviors, particularly if one restricts interest to that occurring within task-oriented teams. In general, it has been found that men engage in more task behaviors and women engage in more social facilitative behaviors (Wood, 1987). Wood suggested that the effect of this difference on performance will depend on the nature of the task, and the degree to which task activities (providing opinions, information, etc.) versus facilitative activities (agreeing, seeking inputs) would contribute to successful performance. Eagley (1995) reported sex-related differences found by researchers with regard to nonverbal behavior, conformity, influenceability, empathy, prosocial behavior, aggressive behavior, and leadership behaviors.

This study will draw from previous findings to formulate predictions regarding the interaction behaviors and effectiveness of same-sex and mixed-gender teams. However, it must be noted that there has been very little investigation of the impact of gender composition in teams that (a) require analysis of quantifiable data, (b) demand interdependent behaviors of team members, (c) have team members with distributed expertise, and (d) are hierarchical in

structure, that is, have team leaders who make the final decision. Yet these attributes typify many organizational and military working teams. The limited amount of research, along with conflicting results, makes it difficult to strongly state the predictions made here; however, the conflicting findings also indicates the need to explore these issues further.

This examination of gender difference in group process also incorporates the investigation of linkages between group process factors, such as communication activity, to group outcomes. The team task in this study requires team members to coordinate their communications in order for team members to acquire the information they need. The assessment of team processes as performance measures which can be related to final outcomes is both critical and challenging, particularly in realistic military settings (Eddy, 1989; Eddy, Dalrymple, & Schiflett, 1992). There is much yet to investigate regarding teamwork, team processes, and team performance (Guzzo & Salas, 1995; Salas, Dickinson, Converse, & Tannenbaum, 1992).

There is some empirical evidence that differences in communication patterns can be a source of ineffectiveness within military aircrew (pilot and copilot) dyads (two-person teams). Differences in status (rank) were found to be a source of ineffective communications (Kanki & Foushee, 1989; Foushee, 1984). Senior officers were not as likely to solicit or incorporate the input from junior officers and junior officers were likely to be passive in their communications. Differences in status has also been an explanatory mechanism for gender differences in communication (Wood, 1987), in that men's propensity for task behaviors may stem from initial perception of higher status along with a striving to maintain or increase status. Lower status members were described as contributing more facilitative behaviors as opposed to task activities. This finding can be placed within a general trend regarding differences in perceptions of power, and is a possible source of differences in communication patterns between women and men.

Other sources which may contribute to gender differences in communication include findings regarding gender differences in communication in general, such as everyday conversation. These differences are generally consistent with stereotypes of feminine and masculine behavior. Women are seen to be more nurturing, emotionally expressive, and having more interpersonal sensitivity, whereas men are seen to be more assertive, independent, and impersonal. These differences have been upheld to some degree (Wood, 1987; Eagley, 1995), yet there is much overlap between the sexes, and much is unknown as

to the source of these differences. From the standpoint of social role theory, team members may conform to traditional gender role behavior, especially in a mixed-sex team.

In this study, differences in gender composition are expected to result in differing communication and coordination styles, which in turn are expected to account for differences in outcomes. These processes will be traced through measures of team communication, coordination, and decision accuracy. Results from this study will contribute to a theoretical understanding of team performance processes. Results will also suggest sources of inefficiencies which can be considered and addressed through changes in policies and/or training.

This study is relevant to the changing demographics of US military operations. While at this time women comprise no more than 15% of Airborne Weapon And Control Systems (AWACS) crewmembers, it is reasonable to expect this percentage to increase. It has been projected that by the year 2000 the workforce is expected to be almost completely gender-balanced (Jackson, May and Whitney, 1995); this trend should be reflected in military as well as private-sector settings. At this time, however, there is a reversal of this trend, with fewer women AWACS members now than in previous years.

This report is an interim report describing progress so far (1 Jan 95- 1 Aug. 95). The data collection has just been completed; therefore results are not yet available. The background and method will be described in this report. The final report will be available in mid-1996.

Background

Communication, coordination, and team effectiveness

Concepts such as communication effectiveness and coordination are intuitively linked to team performance. Communications have been described as "mediating" team performance in aircraft cockpit crews (Foushee, 1984; Kanki & Foushee, 1989). An interesting finding by Kanki and Foushee was that two-person dyads which were supposed to represent the "high fatigue" condition performed better than the "low fatigue" dyads. This was explained as due to the fact that the high fatigue conditions had members who had recently flown together and were reporting for the study straight off a mission together, while the low fatigue members were rested, but not familiar with each other. Communications also differed between the two groups, such that the high fatigue/familiarity teams had more effective communications

(fewer utterances, more task-related utterances). This is not to say that fatigue did not have an effect. Fatigue has been demonstrated to have significant effects, especially when fatigue disrupts the circadian rhythm (Price & Holley, 1990; French, personal communication, 1995). This simply illustrates the importance of team processes and the need to understand the knowledge, skills, and characteristics that underlie effective team performance.

There have been several other studies linking conceptualizations of communication and coordination to performance. These studies are reviewed and discussed in detail by McIntire & Salas (1995) Salas et al. (1992), and by Prince, Chidester, Bowers, & Cannon-Bowers (1992). It can be seen that there are definite relationships between these measures of team process and team performance. It can also be seen that several approaches are available for the measurement of these constructs.

Some basic distinctions can be made among the varying conceptualizations and measures of communication and coordination. First, one can distinguish between coordination demand and coordination performance. Coordination demand can be described as a task characteristic, which indicates the degree to which the task requires coordinated performance from the members. It can be represented as an ideal state representing the degree the task require members to interact with each other if the team members were behaving as efficiently as possible. Coordination demand is often represented by the degree to which the team members are interdependent (Saavedra, Earley, & Van Dyne, 1993). Coordination demand can also be captured by more specific quantitative techniques, such as Petri Nets, Neural Networks, and other modeling techniques (Covert, Craiger, & Cannon- Bowers, 1995). These modeling techniques provide a more specific, and quantitative approach to the measurement of both coordination demand (the ideal state) and coordination performance. Quantitative indices can be obtained for both ideal and actual behavior, and measures of discrepancy can yield an index of efficiency. However, this technique can be complex and rigid, if situations are lengthy and/or highly dynamic.

Coordination performance represents the actual performance of the team. This is often assessed through examination of communications (Kanki & Foushee, 1989) or through subject matter expert observational ratings (Salas et al. 1992). Observation of actual behaviors could also be modeled through the quantitative approaches used to model ideal coordination behaviors (Covert et al., 1995). Coordination performance is the assessment of efficiency and task accomplishment. This can become quite complicated and challenging when the task becomes complex and /or ambiguous. For example, what if the task could be accomplished

by a variety of efficient strategies? Modeling can also become difficult when a task is dynamic. Wartime command and control maneuvers are an excellent example of a situation which may have underlying rules of engagement, yet still require individual judgment and flexibility under changing circumstances. Teams in realistic settings often must work with uncertain information and changing environments, under conditions of high stress and time pressure (Orasanu & Connolly, 1993). Team members must be able to recognize changes in their environment, communicate concerns, and problem-solve on the fly. In short, these considerations can make it difficult to (a) anticipate the tasks which will confront team members, (b) assess the coordination demand of a given task (multiplicity of options), and (c) assess the coordination performance within these dynamic contexts.

A team may be very efficient at relaying quantitative information yet still not accomplish the task. Yet the assumption is that a well-coordinated team must be able to work together even when the environment is in flux, and this may include assessing their environment, informing each other, problem-solving, and generally working with flexibility within a dynamic task (Prince et al, 1992).

In this study, the team process measures will include measures of team communication and coordination. These measures will reflect the degree to which teams exchange information efficiently and effectively. This team task required team members to (a) provide and procure information and (b) accurately interpret that information. For this reason, communications are examined for more than just efficiency. Communication will be examined for the degree to which team members (a) develop strategies for efficient routing of information, and (b) inform each other as to how to interpret information, and share their expertise.

Gender differences in communication

It has been found that diversity in general often has a deleterious effect on group process and group outcome. Diversity has been found to be associated with lower cohesiveness and more negative attitudes (Jackson, 1992). They have also been described as having fewer communications and segregated informal communication networks (discussed by Jackson, 1995). Yet mixed-gender teams have also been found to perform better than same-gender teams (Wood, 1987).

Even if results were consistent with regard to gender and team performance, there would be a need to identify the reason why these differences occur. The existence of

conflicting results underlines the importance of tracing the impact of gender differences on team processes as well as team performance. In her meta-analysis of sex differences in group performance, Wood (1987) suggested that differences between teams of differing gender may be due in part to differences in communication patterns. Wood described several studies where male team members appear more likely to display task behaviors such as providing suggestions, whereas female members were more likely to display social behaviors such as agreement, facilitating input from others, and friendliness. The impact of these differences on team performance may depend on the nature of the team task, the degree to which social activities facilitate or impede performance, and the degree to which the setting encourages gender-role behavior. For example, a single female in an all-male team may facilitate the expression of traditional gender behaviors on the part of both males and the female.

Status. The effects of role conflict can also be described as effects of status differences. Role conflict can influence the expectations of self and other, and these expectations can determine the status of team members. Status within a team has been shown to affect communication patterns. High-status members tended to speak more often, criticize more often, be more persuasive, and be evaluated by other team members more highly (Jackson et al. 1995; Levine & Moreland, 1990).

More specifically and consistent with findings described above, is the prediction that in mixed-gender teams the gender in the majority will underutilize the minority gender. It has been suggested that the presence of a "solo" member is a unique configuration that deserves attention in itself (Jackson, et al, 1995). In this case, the presence of a minority member is expected to enhance the effect of role conflict, particularly in teams with a single female subordinate. In general, patterns are expected such that male members underutilized the communications of female members when the female is the minority member. When the three-member teams include two women, they in turn are expected to communicate and coordinate more with each other than with the single male.

Gender differences in communication as relating to performance. Jackson, May, & Whitney (1995) provide a useful framework for the investigation of gender differences within teams. Jackson discusses linkages among (a) aspects of diversity (task- versus relations-related), (b) mediating states (task versus relations-related), (c) short term behavioral manifestations (task versus relations-oriented), and (d) longer-term consequences. Within this framework, the study of gender differences can be examined at the individual, dyadic, and team level. Using this framework, gender differences would be classified as a (a) readily

detectable attribute which is (b) relations-oriented. Differences in communication are expected to occur as a result of gender differences; in turn, differences in communication efficiency and effectiveness are expected to result in differences in performance outcomes.

Measures of team processes within this study include the core constructs specified within the Multi-level theory of team performance (Hollenbeck et al, 1995; Ilgen, Major, Hollenbeck, & Sego, 1995). This includes (a) the degree to which individuals and teams are well informed about the decision (informity), (b) leader sensitivity to subordinate expertise (dyadic and hierarchical sensitivity), and (c) decision accuracy of team members. This study also includes measures of communication / coordination efficiency and effectiveness, and analysis of communications for strategy development and the sharing of expertise. These measures of individual and team performance will serve as a theoretical foundation for the specific hypotheses regarding women, role conflict, and impact on team performance.

Method

Research design.

This study comprises phase one of a two-phased investigation. The overall goal will capitalize on the advantages of using high-fidelity realistic simulations of AWACS tasks using the Aircrew Evaluation Sustained Operations Performance (AESOP) facility and investigations performed with a more generalizable team task simulation, the Team Interactive Decision Exercise for Teams Incorporating Distributed Expertise (TIDE2). The development of TIDE2 was funded by the Office of Naval Research (ONR). The combination of the realistic and complex AESOP task with the highly controlled and manipulable TIDE2 will optimize assessment of construct validity and generalizability.

The first phase of this study involves the performance of teams on a laboratory synthetic task developed by faculty at Michigan State University. This task, the Team Interactive Decision Exercise for Teams Incorporating Distributed Expertise (TIDE2), enables a tightly controlled study of team processes, with clear-cut measures of communication, coordination, and team effectiveness (Ilgen & Hollenbeck, 1993). The TIDE2 task was adjusted to enable measurement of team process constructs which will also be contained in the realistic AESOP simulator, thus allowing comparisons from a low-cost tightly-controlled synthetic task to a complex realistic task. Driskell and Salas (1992) provide a good discussion

of the value of team research conducted in the laboratory, when essential constructs are included in the team task.

For the TIDE2 study, 40 three-person teams were trained to perform the TIDE2 task. 120 team members were assigned to one of 6 gender configuration categories: First, teams were generated that had either 3, 2, 1, or 0 Females. This provides all configurations of gender within 3-person teams. Then, of the mixed gender teams (having 1 or 2 females), 1/2 were led by females, the other by males, to form the following six cells: (a) all female team (female leader), (b) two females (female leader), (d) two females (male leader), (e) one female (female leader), (f) one female (male leader), and (g) all male (male leader). In this way hypotheses can be investigated with regard to differences in communication and coordination of teams with female versus male leaders. In addition, within-subject manipulations included varying task characteristics of time pressure and ambiguity of information. Three teams had to be discarded due to malfunctions of the computer and one team was a decided outlier in performance and will be examined on a case-study basis. This left 36 teams, six teams for each condition.

TIDE2 Synthetic team task.

TIDE2 was developed in order to study team decision making dynamics in a hierarchical team comprised of members with distributed expertise (see Hollenbeck et al, 1995; Ilgen & Hollenbeck, 1993, for in-depth description and rationale). The TIDE2 software enables networked computers to present subjects with a series of team decision tasks.

For this study, the TIDE2 was configured for three-person teams trained to assess the threat level of "incoming aircraft" which are presented to them. In addition, the aircraft informational cues were adjusted to reflect information more consistent with Air Force AWACS terminology. These modifications were sponsored by the Air Force Office of Scientific Research (AFOSR).

Subjects were first trained to understand and interpret the information cues. These cues include characteristics such as speed, direction, location, type of radar, altitude, and rate of altitude change. Cues are listed in Table 1. They then learn how to use TIDE2 capabilities to access information about the decision object and to communicate information to other team members. Subjects may request and send aircraft information to other team members using automated procedures. In addition they may also communicate with each other via text messages.

For each aircraft, team members gather and share information, then send their recommendations to the team leader, who makes the final decision. Seven decision alternatives range from "ignore" the aircraft to "defend (shoot it down)." This software allows manipulation of information access, information ambiguity, inter-member dependency, inter-member conflict, role status, and time pressure. Measures of communication and coordination efficiency are automatically generated, as are measures of individual and team proficiency, for single and grouped aircraft.

Manipulation of interdependency.

As Salas has pointed out (Salas, Bowers, & Cannon-Bowers, 1995) the definition of a team includes a certain degree of interdependency. In this case, as communications and coordination were of interest, the TIDE2 task was configured to necessitate the coordination of information among the team members. Each of the three team members were trained to be specialists in interpreting three cues, and were given only general information about the other six cues. While each of the team members could measure five cues, they could only measure one of the three cues they needed. They had to get the other two cues from either of the other two team members (see Table 2). In addition, if they wished to correctly interpret the additional cues that they can measure, they would have to be "taught" how to interpret those cues from the other team members. Thus, two types of coordination strategies are apparent (a) specialists: team members send required cue information as efficiently as possible and stick to their specialty, or (b) generalist: team members learn how to interpret cues outside their specialty by sharing their expertise.

Coordination as a team task. Interdependency was created in this task in order to investigate the coordination patterns of the team members. For example, each team member could procure his/her required information from EITHER other team member. Thus if the other team members are male and female, we can assess the degree to which the male or female team member is chosen for information exchange. In doing this we created the situation where a team must generate their own coordination strategy. They were not told a priori- you must get this information from person A and that information from person B. Team members had to find out what other team members had and what they needed, then work out a system for efficient coordination.

Knowledge / Performance measures.

The measures of team processes and outcomes are embedded within the TIDE2 scenario and relate to theoretical constructs in an existing paradigm of team distributed decision making (See Hollenbeck et al, 1995), with a few minor modifications to fit these scenarios. These include measures at the individual, dyadic, and team level.

Strategic Awareness. Strategic awareness is conceptualized as the degree to which team members have knowledge of the needs and resources of all team members. Items were developed to assess this knowledge through a questionnaire administered after the task. Items provided the nine cues and asked teammates to respond to the following questions.

“which cues can Alpha measure”

“ which cues can Bravo measure”

“which cues can Charlie measure”

“which cues did Alpha need”

“which cues did Bravo need”

“which cues did Charlie need”

This strategic knowledge is required in order for team members to coordinate their behaviors efficiently and effectively.

Communication behaviors: Automated information transfer functions. TIDE2 allows the transfer of aircraft-related communications through automated functions which require no speech or typing. Team members can query each other (ask for particular information to be transmitted to them), transmit information, and receive information. TIDE2 also generates measures based on interactions. TIDE2 then provides descriptive statistics of these behaviors for each dyad and for the team as a whole. For example, one will have the number of times Alpha queried Bravo, Alpha queried Charlie, Bravo queried Alpha,. Bravo queried Charlie, Charlie queried Alpha, and Charlie queried Bravo. Categories are as follows.

Query - Where one team member asked for specific information from another, using the “query” function.

Receive- Where one team member received a query, transmit, or text message from another.

Transmit- Where one team member transmitted information to another using the “transmit” function.

Message- Where one team member sent a text message to another.

Slight - Where a query was sent but was not “received” by the recipient.

Unresponse- Where a query was sent, and was received by the recipient, but was not responded to (The query asks for information, this information was not sent).

Forget - Where a query was sent, and was received, and was responded to (the recipient sent the information) but the response was not received.

Learns - A completed 4-action loop: a query was sent, was received and responded to; the response was received by the team member who sent the query.

Lecture - A 2-action loop, where information is transmitted (without the query) and received by the recipient.

Communication efficiency. There will be three ways in which communication efficiency will be measured. Two are based on communication behaviors and the second was based on perceptions provided by the teammembers after the session.

(a) Implicit coordination. One measure of communication effectiveness assessed the degree of implicit coordination among the team members. This is achieved by using the following formula:

$$\# \text{ slights (1) } + \# \text{ unresponses (2) } + \# \text{ forgets (3) } + \# \text{ learns (2)}$$

This is based on the rationale that when team members are implicitly coordinated, they will send information required by team members without being asked. The requirement for this implicit coordination is that team members know what other team members need. Therefore in a team that is implicitly coordinated, the communications would ideally consist of "lectures", where information is sent and received in an efficient 2-motion effort. One team member sends, another receives the information. This is consistent with the notion of implicit coordination as described by Kleinman and Serfaty (1989) and Morgan and Bowers (1995).

A slight is a wasted motion because one member queries another and that query is not received, therefore the query action was one wasted motion. An unresponse is counted as two wasted motions because a query is sent, the query is received, but the information is not sent. Therefore two motions were performed, without any information being transmitted. A forget is counted as 3 wasted motions because a query is sent, the query is received, the information is sent, but the information is not received by the person who requested it. A learn is counted as 2 wasted motions because a query is sent and received before information is

sent and received. So far this measure has demonstrated internal consistency (coefficient alpha is .75; Hollenbeck 1995, personal communication).

(b) "Minimalist" measure of efficiency. This measure is based on an assumption that fewer actions are more efficient. In the measure of implicit coordination above, as long as the team members are sending information without being asked, the team will be efficient. Team members will not be considered inefficient if they send additional information that is not required for their expertise. In contrast, this measure simply assumes the fewer actions made the better. In this case, for each incoming aircraft, team members had to receive two pieces of information (the two they needed) and send information to others. The most efficient way this can be done is if each team member sent two pieces of information and received two pieces of information. This would total 6 transmits and 6 receives for each aircraft. Therefore, for a set of 10 aircraft, the most efficiently this can be done would be with 60 receives and 60 transmits. The formula used to calculate efficiency follows, and reflects the average number of excess motions per decision:

$$\frac{\# \text{Queries} + (\# \text{transmits} - \text{ideal } \# \text{transmits}) + (\text{receives} - \text{ideal } \# \text{receives})}{\# \text{decisions}}$$

The above formula is descriptive of excess motions as being the difference between the actual number of motions versus the minimal number of motions required to get the information to the right members. However, in correlational analyses the subtraction of a constant make no impact; therefore this formula can be simply stated as the total number of motions. This measure is expected to correlate with the first measure of implicit coordination. The difference between this measure and the previous one is that in this measure text messages are included as inefficiencies (the # receives includes receipt of transmits, queries, and text messages), and any lectures that are unnecessary would also add to the inefficiency. The first measure of implicit coordination is expected to be particularly suited to situations where a high amount of information exchange is beneficial, whereas the second measure of efficiency has the assumption that fewer motions are better. It is expected that high performing teams will likely be inefficient by both measures during the beginning of the task when team members are faced with developing a coordination strategy.

(c) Communication Efficiency: perceptions. Each team member responded to items in a questionnaire that attempted to ascertain efficiency. Items were tailored for each station (Alpha, Bravo, Charlie) with regard to what each station needed from others. For example, Alpha's items included the following:

"did you regularly receive corridor status when you asked for it?"

(1) from bravo (always, often, usually, sometimes, never)

(2) from charlie (always, often, usually, sometimes, never)

"did you regularly receive corridor status without having to ask for it?"

(1) from bravo (always, often, usually, sometimes, never)

(2) from charlie (always, often, usually, sometimes, never)

Team (Specialist) Informity: Data. This is conceptualized as being the extent to which team members received the information required for their expertise. It would be the average across aircraft and team members, number of pieces of information received that was required (minimum = 0, maximum = 6). Note that this conceptualization is based on a specialist strategy where team members would focus on their area of expertise (Hollenbeck, 1995).

Conceptual knowledge. This is the extent to which team members had knowledge of how to interpret the cues they received. While the preceding measure of informity assesses whether or not the member received the information, this measure assesses the extent to which the team member can interpret the cue. This was assessed by a questionnaire at the end, where they were asked the threat levels of each cue, which cues "go together" in an interaction, and how to interpret an interaction. This can be assessed for the special expertise of each member, and for general expertise gained through experience and communication with other team members.

Staff validity. This is the average correlation of team member judgments provided to the team leader with the correct score for each aircraft. This reflects the degree to which team members gave accurate recommendations to the leader (Hollenbeck et al, 1995).

Hierarchical sensitivity. This measure reflects the sensitivity the team leader has as to the competence of other team members, and the degree to which the leader decision weights the judgments of the other team members. First one identifies the ideal weights that should have been used by the leader, given the recommendations he or she received. This can be done by regressing the correct decision with the subordinate recommendations for each aircraft. When averaged across aircraft one arrives at a set of weights that reflects how the

subordinate judgments should have been weighted. Then one performs the same regression using the leaders judgment as the criterion, which results in the set of weights reflecting the leader's weighting of subordinate judgment. If the leader weighted the recommendations in an ideal manner, there would be little if any difference between the leader weights and the ideal weights. However if there are large differences in the weights, the leader is not weighting the information in an effective manner. For example if there were an incompetent member who consistently gave wrong judgments, the regression against the correct answer would give a small weight to that member. If however the leader tended to agree with the incompetent member, then that regression would result in a larger weight for that member. The smaller the differences between ideal and leader weights, the higher the hierarchical sensitivity (Hollenbeck et al, 1995).

Relationships among group process and outcome variables. Relationships are expected to be consistent with the Multi-level theory of team performance (see Figure 1; discussed in detail in Hollenbeck et al, 1995). Figure 1 demonstrates the critical role of three "core" variables. Overall decision accuracy is expected to be mediated by these three variables: team informity, staff validity, and hierarchical sensitivity. Other variables in the "outer ring" are expected to influence team effectiveness through their impact on these core variables.

In this study, strategic awareness is expected to relate to communication efficiency. When strategic awareness is high, communication efficiency is expected to be more efficient than when strategic awareness is low. Communication efficiency is expected to influence the core variable of team informity, in that the more efficient the communication, the more likely the team is to be informed. Also, communication efficiency is expected to be more highly related to informity under high time pressure. Conceptual knowledge is expected to be related to staff validity, in that the more knowledgeable the team regarding interpretation of cues, the more valid will be their assessments. A general trend is expected that teams of women would have lower communication efficiency, but higher strategic knowledge, higher conceptual knowledge, and higher informity due to increased communications.

Analysis of text messages.

Text messages were coded based on the scheme described by Ilgen & Hollenbeck (1993), with a few minor modifications. Figure 2 demonstrates the flow chart representing the scheme by which text messages were coded. Appendix 1 describes in detail how the text

messages were coded. Text messages were coded for several teams by separate coders (the authors). The first team had a few statements that were coded differently (% agreement = .94). This led to discussion, further clarification, and elaboration of the coding scheme. Subsequent teams were coded at an even higher level of agreement (99%).

The text messages will be analyzed in a number of ways. First, the simple count of text messages are included in the measure of communication efficiency, as the # receives includes the receiving of text messages. In that way, the text messages are interpreted to be inefficient. From the definition of pure efficiency, this is consistent. Text messages are time consuming and once team members know who has what and who needs what (which can be determined without the use of text messages) they are not necessary. However, it is apparent that text messages provide rich information regarding group processes. In these messages one finds indicators of group morale (positive feedback/encouragement), the development of coordination strategies (for example, the agreement to send information every time without being asked), the sharing of expertise (how to interpret information that is not of one's specialized training), and the extra-role behaviors, such as pleas for and offers of help. These areas will be related to performance, and to gender differences at the dyadic and team levels.

Communication/coordination and gender differences.

Gender differences in communication patterns will be investigated first at overall team level and then at the dyadic level. The following section provides a general overview of comparisons which will be made.

Comparisons to be made at the team level. A preliminary comparison will be to compare teams of differing gender mix on the following team level indices. First the number of automated and text communications will be examined. In addition the indices of communication efficiency, informity, and other measures of group process will be compared. Text messages will be examined for differences in social communications, information exchange, strategy development, and helping behaviors. Some comparisons to be made include:

- (a) Overall number of communication behaviors.
- (b) Number of social communication behaviors.
- (c) Communication efficiency
- (d) Overall degree of information exchange.

(e) Number of helping communications (requests for help and queries as to whether team members need help).

(f) Sharing of expertise regarding interpretation of information (through text messages).

Comparisons at the dyadic level. In addition to comparing teams composed of different gender configurations interactions among same-sex versus mixed-gender dyads will be compared. This yields a more powerful analysis as all teams can be included in the comparisons, and there are three dyads (alpha & bravo; bravo & charlie; alpha & charlie) within each team, increasing the N to 120 comparisons across teams. Comparisons will be made with regard to:

- (a) Number of learns and lectures among same-sex versus mixed-sex dyads.
- (b) Number of inefficiencies.
- (c) Number of social communications.
- (d) Degree of information exchange.
- (e) Number of helping communications.
- (f) Sharing of expertise.

For example, when there is one female subordinate, within-team communications are expected to differ from that of all-male teams in the following manner. First one would assess the number of messages, receives, queries, and transmits among the team members:

ALPHA (male)	BRAVO (male)	CHARLIE (female)
#messages to B	#messages to A	#messages to A
#messages to C	#messages to C	#messages to B
#receives from B	#receives from A	#receives from B
#receives from C	#receives from C	#receives from A
#queries to B	#queries to A	#queries to A
#queries to C	#queries to C	#queries to B
#transmits to B	#transmits to A	#transmits to A
#transmits to C	#transmits to C	#transmits to B
_____	_____	_____
total# to B	total # to A	total # to A
total# to C	total # to C	total # to B

Expect: total# from A to B > total # from A to C
total # from B to A > total # from B to C
total # slights, unresponses, and forgets higher to C

Comparison of Female-led versus Male-Led teams. There is evidence regarding gender differences in leadership style (Eagly & Johnson, 1990). Eagly found that women tended to adopt a more democratic style, whereas men tended to have a more directive or autocratic style. In this team task there is no face-to-face communication therefore these tendencies may not generalize to this computer-mediated situation. However, certain characteristics can be examined, such as the (a) quantity, configuration, and content of text messages, and (b) coordination strategy adopted by the team. It is predicted that teams with female leaders would be more communicative in general and more likely to develop a generalist strategy (more complete sharing of information) This would result in a higher amount of communication and coordination activity for female-led teams:

The effect of team leader gender is expected to depend in part on the gender of the subordinates. For example the effectiveness of a Female leader may differ depending on whether the two subordinates are male or females. Female leaders are expected to be more critically evaluated by male subordinates. The same communication patterns are expected as when there are two males and one female (fewer communications from the males to the female). In addition, text messages will be compared for critical remarks regarding the leader or leader decisions.

The approach to conducting the analyses indicated above will be described in full detail in the final report. At this time, data has been collected and is being prepared for analyses.

Results

Data collection has just been completed as of August 17, so very little is currently available. Rather than provide sketchy and possibly misleading results at this time, results will be provided and interpreted within the final report.

Discussion

Data collection has just been completed. Preliminary results are sketchy and incomplete, and should be considered only as additional explanations as to how the data will be analyzed. The final technical report is due in April 1996, and complete results will be provided and discussed within that report.

There is also an ongoing effort to run phase 2 of this study, which studies the performance of teams of AWACS weapons directors within a realistic simulation. This effort has been impeded by operational issues and demands. Subjects must be experienced AWACS weapons directors, usually acquired through Tinker AFB, OK, and agreement for the use of these subjects has been delayed until January 1996.. This career field has suffered significant attrition, and current weapons directors are in demand and sent on temporary duty assignments beyond the usual allowances. Furthermore, the past percentage of female weapons directors (15%) has dramatically been reduced to less than 5%. We are anticipating difficulty in obtaining balanced gender teams and may have to redesign our study to include gender as a nested variable under rank. The total population of ALL weapons directors is estimated to be approximately 600, which leaves only around 40 women weapons directors assigned world-wide.

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Table 1. CHARACTERISTICS OF AIRBORNE AIRCRAFT

aircraft cues	Definition	Range
RANGE	<u>Distance from your base operations.</u> In general, aircraft that are closer are more threatening	0 - 600
ALTITUDE	<u># feet aircraft is above ground</u> In general, aircraft that are low in altitude are more threatening	100 - 99,000
RADAR CROSS SECTION	<u>Estimated size</u> In general, smaller aircraft are more threatening	0 - 12
CORRIDOR STATUS	<u>Miles from center of civilian corridor</u> In general, aircraft far outside the civilian corridor are more threatening	0 - 25
ELECTRONIC SECURITY MEASURE (ESM)	<u>Indicates threat of radar signals</u> In general, aircraft with high ESM values are more threatening	0 - 999
# OF AIRCRAFT	<u>Estimated number of aircraft</u> In general, a higher number of aircraft is more threatening	1 - 20
HEADING CROSSING ANGLE (HCA)	<u>Indicates direction of aircraft</u> In general, the higher the HCA , the more directly the aircraft is headed toward the base, which is more threatening.	0 - 180
RATE OF ALTITUDE CHANGE (RATE^ALT)	<u># feet/minute ascending or descending</u> In general, the higher the rate of altitude change the more threatening	0 - 10,000
SPEED	<u>Miles per hour</u> In general, the faster the aircraft the more threatening	0 - 800

Table 2.

CHARACTERIZATION OF WHAT EACH TEAM MEMBER CAN INITIALLY MEASURE AND WHAT THEY NEED:

ALPHA	BRAVO	CHARLIE
can measure:		
range	altitude	Radar C.S.
HCA	corridor status	corridor status
Speed	# aircraft	# aircraft
ESM	ESM	HCA
Rate^alt	Rate^alt	Speed

is responsible for (needs):

range/corridor st/# aircraft | altitude/HCA/Speed | Radar C.S./ESM/Rate^alt

MOST EFFICIENT: EACH MEMBER SENDS TWO PIECES AND RECEIVES TWO PIECES OF INFORMATION

Appendix 1: Analysis of Text Messages

The first classification point is based on whether the message is task-related (A) or social (B). The social messages are then classified as strictly social or task-supportive, as follows:

B-1: Strictly social: Statements such as:

- "Hello"
- "I am hungry (tired, bored, happy, etc.)"
- "Are you doing anything later"
- "I think I know you from somewhere"

B-2: Task-supportive: statements of encouragement, feedback, reflections on performance. etc.

- "Good job!!"
- "These are frustrating data too much in conflict"
- "Give me an answer"
- "Sorry about sending size my finger slipped"
- "Are we good or what?"
- "We screwed up that last call"

The task-related statements (A) were then categorized as either seeking (A-1) or providing (A-2) information. This enables quick comparisons of efficiency and effectiveness of information exchange based on (a) both seeking and providing information (explicit coordination) versus (b) providing information with explicit requests (implicit coordination).

Both information seeking (A-1) and information providing (A-2) categories were further categorized by the type of information:

INFORMATION SEEKING:

A-1-2: STRATEGY: statements seeking information /suggestions with regard to strategic SHARING of information. These statements refer to how to improve the information transfer function (coordination of information). examples:

- "Do you need judgments earlier?"
- "Do you always need radar?"
- "what do I do now?"
- "Did you have what you need?"
- "Did you get speed last time"
- "Do you need speed everytime?"

Statements requesting aircraft information are usually coded as A-1-5a (see below) but the inclusion of "always" or "everytime" or "earlier" etc. qualifies the statement for this category (A-1-2) as well.

A-1-3: ROLES: statements seeking information as to who can measure what, and who needs what. examples:

“Do you have speed and direction?”

“Who has range?”

“What can you measure?”

“I have radar who has speed?”

“Who has speed, altitude, range, corr st, and HCA”

A-1-4: RULES: statements providing information as to how to INTERPRET information (cues and cue interactions). examples:

“what is threatening speed”

“what is threat direction”

“what affects threat range”

“what is threat speed and direction”

“what goes with HCA?”

A-1-5: AIRCRAFT: statements seeking information regarding a particular aircraft. This category is further divided into statements that could have been transmitted more efficiently using “transmit” function (A-1-5a) versus statements that could not be transmitted automatically (contains uncertainty, etc.; A-1-5b)

A-1-5a: examples

“ please send speed”

“ need HCA”

“ what is range”

A-1-5b: examples

“what do you think?”

“what is your judgment”

“is speed dangerous”

“ignore or review?”

“just tell me if speed is threat don’t send numbers”

A-1-6: CLARIFICATION: statements seeking clarification of a previous message or behavior, such as:

“why did you do that?”

“did you get it in time?”

“what in hell are you talking about?”

“what??”

PROVIDING INFORMATION

A-2-2: STRATEGY: statements providing information /suggestions with regard to strategic SHARING of information. These statements refer to how to improve the information transfer function (coordination of information). examples:

“I need judgments earlier”

"Do not send radar"
"I will send altitude everytime"
"Please always send direction"
"Let's concentrate on our specialties"
"If you have size transmit to alpha from now on"
"When something violates your rule bigtime tell me"

Statements requesting aircraft information are usually coded as A-1-5a (see below) but the inclusion of "always" or "everytime" or "earlier" etc. qualifies the statement for this category (A-1-2) as well.

A-2-3: ROLES: statements providing information as to who can measure what, and who needs what. examples:

"I need speed and direction always"
"I don't have range"
"Bravo has range"
"You need radar, I got it"
"I can measure speed, altitude, range, corr st, and HCA"

A-2-4: RULES: statements providing information as to how to INTERPRET information (cues and cue interactions). examples:

"400-800 is threat"
"if speed is safe then ignore direction"
"range and corridor status go together to determine threat"
"100-1000 is dangerous altitude but look at rate change too"

A-2-5: AIRCRAFT: statements providing information regarding a particular aircraft. This category is further divided into statements that could have been transmitted more efficiently using "transmit" function (A-2-5a) versus statements that could not be transmitted automatically (contains uncertainty, etc.)

A-2-5a: examples
"speed 450mph"
"defend"
"range is 300 miles"
"ignore"

A-2-5b: examples
"speed is dangerous"
"looks threatening"
"lockon very bad corr st speed and radar"
"ignore or review"

A-2-6: CLARIFICATION: statements providing clarification or acknowledgment that do not readily classify into other categories, such as:

"yes I received your message"

"no I didnt get it"
"im not receiving anything from you"
"ok"
"yes I did"

MORE SPECIFICATIONS:

CUE INFORMATION: Each message is further coded (if applicable) as to whether the message has to do with the overall aircraft or specific cues, as follows

- 0- overall aircraft
- 1- speed
- 2- altitude
- 3- radar cross section
- 4- rate altitude change
- 5- esm
- 6- hca
- 7- corridor status
- 8- # aircraft
- 9- range

For example if a message sought the threatening values of speed (A-1-4) the code would be followed by a /1 to indicate the message was regarding speed. If a message provided information about the aircraft in general (recommend monitor or review- A-2-5b) it would be followed by a /0 to indicate the message was regarding the overall aircraft.

SELF-INITIATED versus RESPONSE. This category indicates whether the message was self-initiated (A) or in response to another (B). This categorization is difficult because text messages can be responses to queries or transmits. However, if it is clear that a text message is in response to another text message, it is coded as a /B, and the message responded to is coded as a /A.

Figure 1. Overview of the multilevel theory of Hierarchical decision making (Hollenbeck et al., 1995)

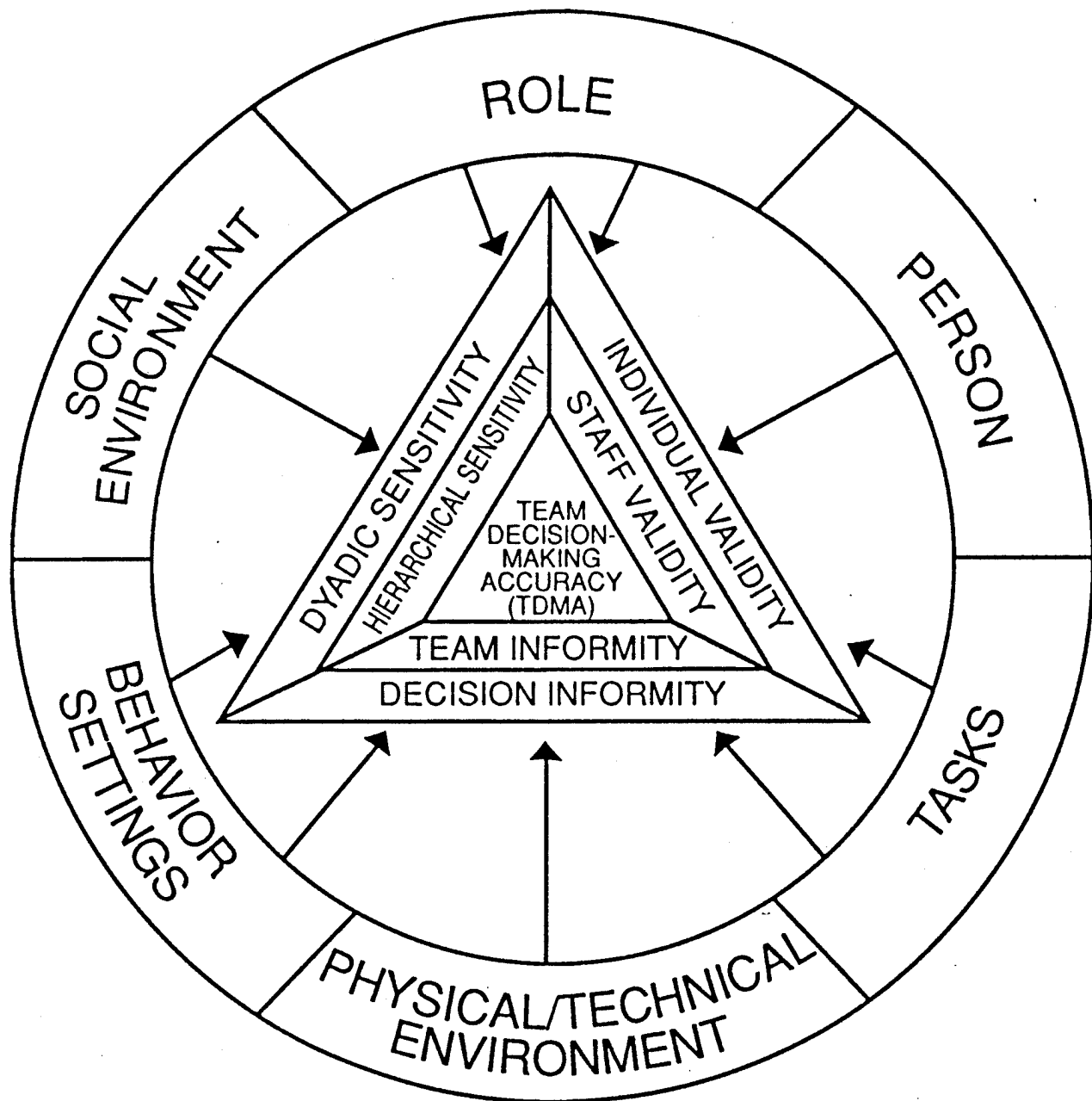
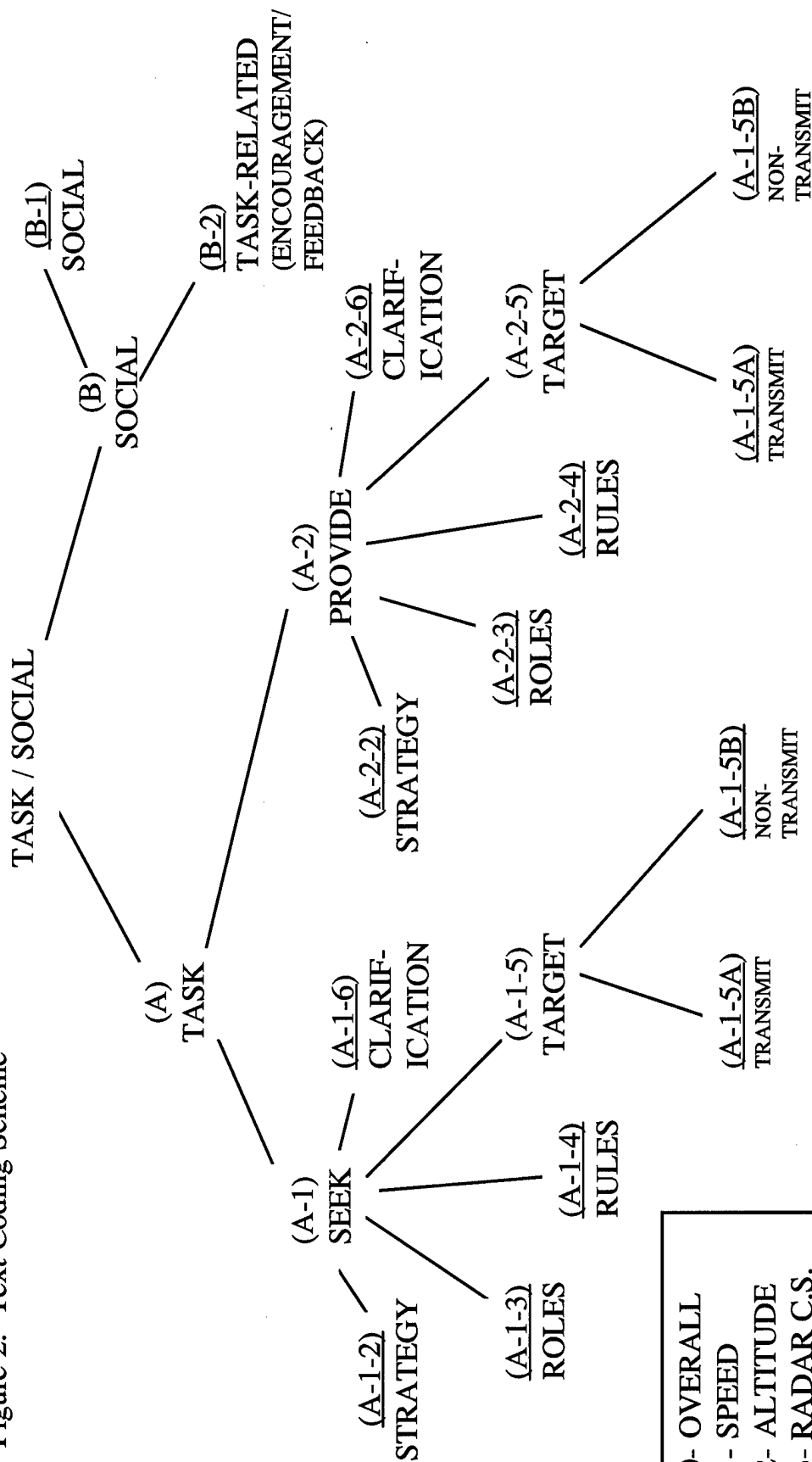


Figure 2. Text Coding Scheme



- | |
|----------------|
| 0- OVERALL |
| 1- SPEED |
| 2- ALTITUDE |
| 3- RADAR C.S. |
| 4- RATE/ALT |
| 5- ESM |
| 6- HCA |
| 7- CORRIDOR ST |
| 8- # TARGETS |
| 9- RANGE |

LAST SUFFIX:
A- SELF-GENERATED
B- RESPONSE
X- UNKNOWN